Small Business Innovation Research/Small Business Tech Transfer

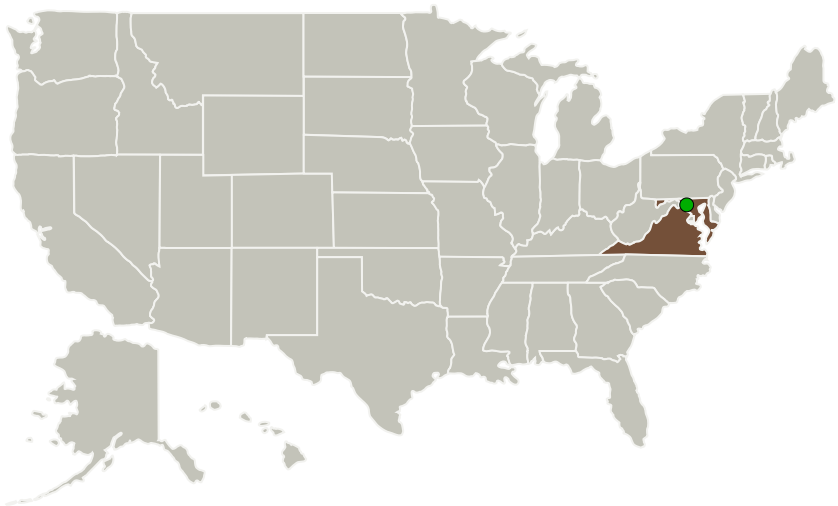
Robust Trajectory Design in Highly Perturbed Environments Leveraging Continuation Methods, Phase I

Completed Technology Project (2016 - 2016)

Project Introduction

Research is proposed to investigate continuation methods to improve the robustness of trajectory design algorithms for spacecraft in highly perturbed dynamical environments, such as near asteroids and comets, where many traditional methods that are often used and taken for granted simply do not work. The continuation is achieved through establishing homotopies between some simple models, for which solutions are easy to obtain, and the full models. We will investigate how sensitivities of the trajectory to the homotopy parameters can be used to systematically and effectively automate the homotopy continuation, improving the robustness of the algorithms. We will also investigate adaptive fidelity models and alternative interpolation-based gravity models, as well as a number of techniques developed by the investigators to speed up the dynamics evaluations. Almost every legacy trajectory design software code used by NASA (e.g., Malto, Copernicus, EMTG, GMAT, etc.) is faced by the dilemma that hard problems simply don't converge without a good initial guess. The gradient-based localized optimization methods used in these software tools require initial guesses that are close to the final solutions. The common practice of using solutions based on simplified models as initial guesses often do not yield convergence if the full problem is solved directly, especially in highly perturbed dynamical environments. In the proposed method, instead of taking a full step from the simple model to the full model, we systematically take smaller steps, and judiciously introduce incremental perturbations. This method is amenable to automation and yields robustness in convergence. The proposed research will greatly benefit NASA and the space trajectory design community in designing high-fidelity trajectories with true ephemerides and force fields.

Primary U.S. Work Locations and Key Partners



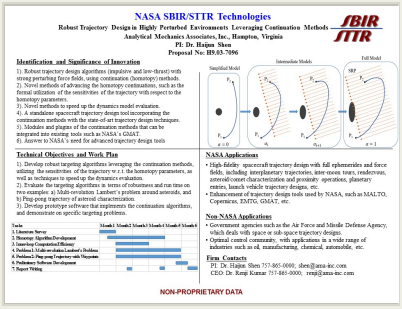


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Table of Contents

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Organizations Performing Work	Role	Type	Location
Analytical Mechanics Associates, Inc.	Lead Organization	Industry	Hampton, Virginia
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations	
Maryland	Virginia

Project Transitions

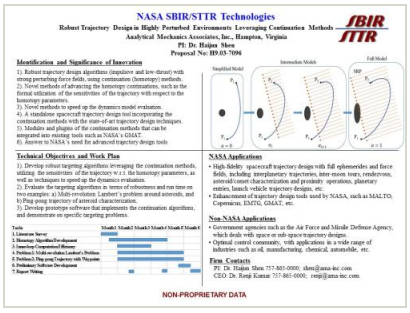
June 2016: Project Start

December 2016: Closed out

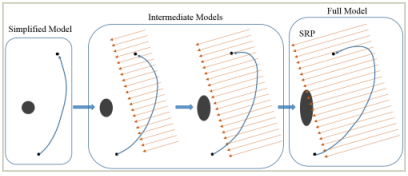
Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/139896)*

Images



Briefing Chart Image
Robust Trajectory Design in Highly Perturbed Environments Leveraging Continuation Methods, Phase I
(https://techport.nasa.gov/image/128070)



Final Summary Chart Image
Robust Trajectory Design in Highly Perturbed Environments Leveraging Continuation Methods, Phase I Project Image
(https://techport.nasa.gov/image/127341)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Analytical Mechanics Associates, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

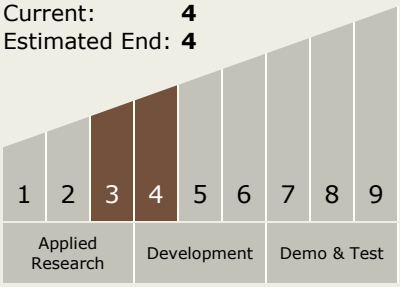
Carlos Torrez

Principal Investigator:

Haijun Shen

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



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Completed Technology Project (2016 - 2016)

Technology Areas

Primary:

- TX17 Guidance, Navigation, and Control (GN&C)
  - TX17.3 Control Technologies
    - TX17.3.2 Dynamics Analysis, Modeling, and Simulation Tools

Target Destinations

The Moon, Mars, Outside the Solar System, The Sun, Earth, Others Inside the Solar System